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Impact of external walls insulation location and distribution on energy consumption in buildings: A case study of Northern Cyprus

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Abstract

This study aims to investigate the impact of walling in terms of insulation location and distribution on energy consumption in building. The number of seven wall assemblies with the same thermal mass varying in thermal insulation location and distribution was studied. Dynamic thermal simulation was employed using EDSL Tas software as the main research tool. Continuous (24 hours) air conditioning and Northern Cyprus climatic references were applied in Famagusta as well. The outcomes revealed that utilization of thermal insulation indicated significant improvement on the overall energy performance of the buildings. It also indicated a significance when locate insulation layer in the outside of the building external walls. This project is the first part of a much larger project that intends to propose the suitable wall construction in the case of Northern Cyprus which not only create a knowledge base of passive techniques in terms of walling but it also address areas of material, thickness and the hybrid technologies.

Keywords: Insulation location and distribution; walling; energy consumption; North Cyprus

Introduction

Due to the today's concern about renewable and non-renewable energy resources on our planet, energy saving becomes a high priority issue all Over the world. Buildings as the major energy consumers, use approximately %40 of total energy use widespread (UNAP, 2007). To reduce the amount of energy consumption in buildings, building components should employ energy efficient concepts which among them external wall thermal insulation plays a crucial role. Most of the previous research works in this area investigated the effect of insulation location on external walls in terms of high time lag and low decrement factor. (Asan, 1998) evaluated one dimensional transient heat conduction equation using Crank Nicolson scheme under convection boundary condition which periodic boundary condition were applied to the outer surface of the walls. Additionally, in his more recent study (Asan, 2000) he evaluated the number of six wall assemblies, based on the same equation scheme and methodology, using one-dimensional Periodic convection boundary condition from maximum time lag and minimum decrement factor point of view. The result shows that dividing same amount of thermal insulation material as two layers instead of one and place them in the mid-center and the outer surface of the wall gives very high time lag and low decrement factor. (Al Sanea and Zedan, 2001) evaluated the effect of insulation location on thermal performance of building walls under steady periodic condition. The thermal performance with insulation layer located in out and inside of a wall was compared in order to assess the best heat performance. Result showed that the thermal insulation location has a minimal effect on mean daily heat transfer rates. (Ozel and Pihtili, 2007) analyzed twelve different wall configurations varying in thermal insulation location. Optimum location was considered according to the high time lag and low decrement factor using implicit finite difference method for multilayer walls during typical summer and winter days. Consequently it was found that placing the insulation layer in the indoor and outdoor surface of a wall with same quantity has better result from the point of maximum time lag and minimum decrement factor. (Ozel, 2014) studied the same method using implicit finite difference under steady periodic condition which resulted in the case that placing insulation layer at the middle of a wall gives the maximum temperature fluctuations in both summer and winter days while placing insulation layer at the outside of the wall surface gives the smallest fluctuation. In a very general study over thermal insulation location, (Kolaitis et al., 2013) made a comparative external versus internal insulation system for energy efficient retrofitting of residential building by a numerical simulations and parametric study where both external and internal insulation system reduce the total energy requirements. In addition, other research work by (Bond et al., 2013) provided the perception of wall layers for enhanced insulating performance employing thirty three different wall assemblies varied in insulation distribution. Less decrement factor ratio and high time lag have been considered efficiently to reduce the thermal insulation materials as well as the energy consumption. Analysis indicates that placing insulation at both inside and outside of the wall gives the best performance besides splitting insulation and mass layers into an increasing number of division. However, continually increasing the number of layers at some points culminated in the performance reduction. In accordance with preceding research works mentioned above and also (Al-Sanea and Zedan, 2001, Saleh, 1990) which specifically focused on thermal insulation location, it is obviously perceived that most studies investigated the optimized insulation location and distribution in terms of high time lag and low decrement factor using steady state methods. Our objective here is to determine the most efficient thermal insulation location and distribution within building's external walls in terms of energy efficiency through a dynamic thermal simulation for some commonly used construction materials in Northern Cyprus cities.

Purpose of the study

According to the deficiency of written constructional code in Northern Cyprus, building sector pursues the traditional techniques and material utilization. Although electricity is one the most expensive issues for the households in the context most of the building components are not equipped with energy efficient strategies such as insulating and etc. According to this scenario, the study here presented deals with the relationship between building energy consumption and the walling in terms of insulation location and distribution. The present study is the first part of a much larger study that intends to propose the suitable wall constructions which not only creates a knowledge base of energy efficient strategies but it also address areas of insulation, material, thickness and the novel hybrid technologies.

Materials and method

A room occupied by one person was simulated as the test room (Fig 1). It is 5m long, 5m wide and 3m high which has four chambers facing four orientation. Each external wall contains a window with a wooden frame and a single pane. Window dimensions are: length = 1m; width = 1.2m, since %20 of floor area was allocated to the openings in order to have sufficient day lighting value. Wall constructions and their thermal property are given in Fig 2. And Table 1. respectively.

Simulation tool

The EDSL Tas version 9.3.2 building simulation program was used. It is an industry-leading building modeling and simulation tool capable of performing dynamic thermal simulation for the world's largest and most complex buildings (Liu, 2007). Tas was developed by the UK department of Energy in 2005. It accurately predict energy consumption, CO2 emissions, operating costs, PMV and occupant comfort.

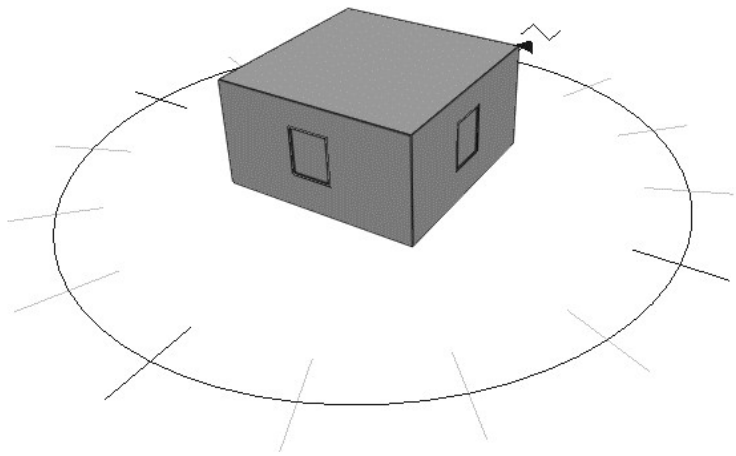

Figure 1. The test room

Internal condition

The thermostat for heating and cooling periods adjusted 21ºC and 24 ºC respectively and the HVAC system adopted in the simulations is an air-conditioner working continuously (24 hours) to maintain a constant condition for each wall assembly.

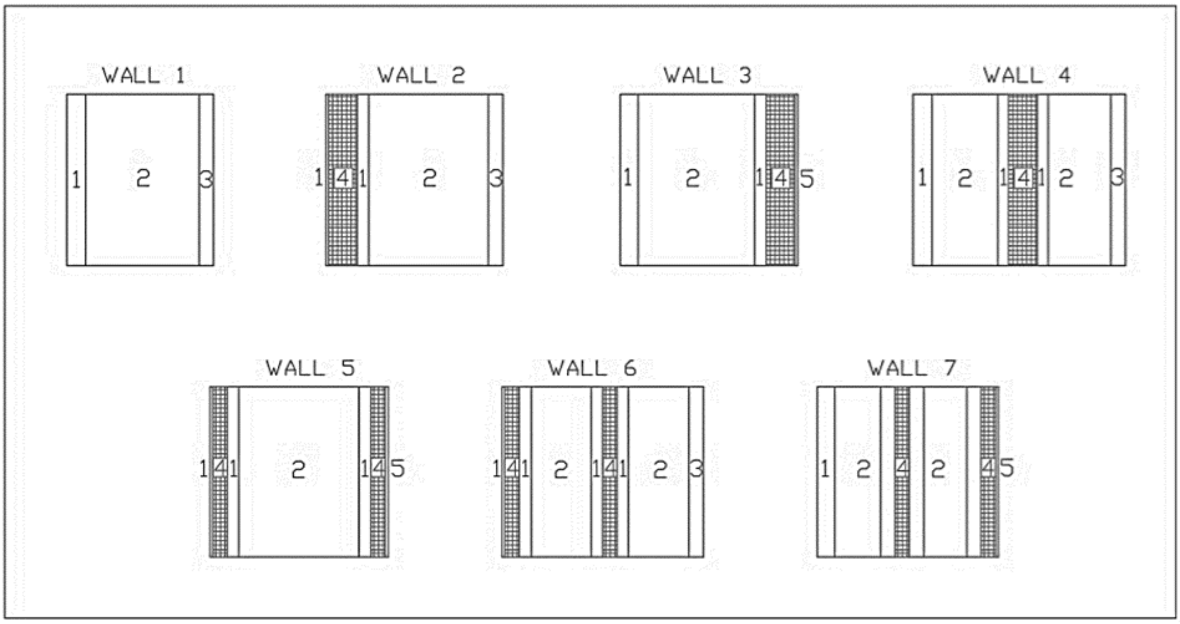

Figure 2. Wall assemblies

Table 1. Thermal property of the materials (ASHRAE and TS 825).

Material	Thickness (m)	Density (Kg/m^{3})	U-value (W/mk)	Specific heat (J/kg.C)
1. Cement Plaster	0.025	2000	1.60	837
2. Hollow Brick	0.20/0.10	800	0.39	920
3. Gypsum Plaster	0.025	1900	0.030	1200
4. Extruded polystyrene	0.05/ 0.25	1400	0.70	837
5. Gypsum Board	0.013	800	0.161	1088

Results

The common wall construction in Northern Cyprus composes of 20cm hollow brick as the massive part plus 2.5cm cement and lime plaster uses for the exteriors. The interiors besides use 2 cm gypsum plaster for the coverage and a finishing which can be a light paint or etc. Few energy efficient concepts may be used but are very limited for personal projects and not used for the mass production. According to this scenario wall 1 is the representative of common walling in the context which is non-insulated (Fig 2). The results of dynamic simulation for wall 1-7 is plotted in Figs 2 and Table 2 in terms of annual energy consumption (heating and cooling). As it is shown, in (Table 2) wall 1 annual energy consumption exceeds 4800 kwh/m^2 while wall 2-7 are approximating 4282 to 4410 Kwh/m^2. Among all assemblies wall 2 had the best performances while wall 2,3,6,7 had very similar results. More over the simulation revealed that wall 3 had the worst performance due to its energy consumption which exceeded 4400 Kwh/m^2.

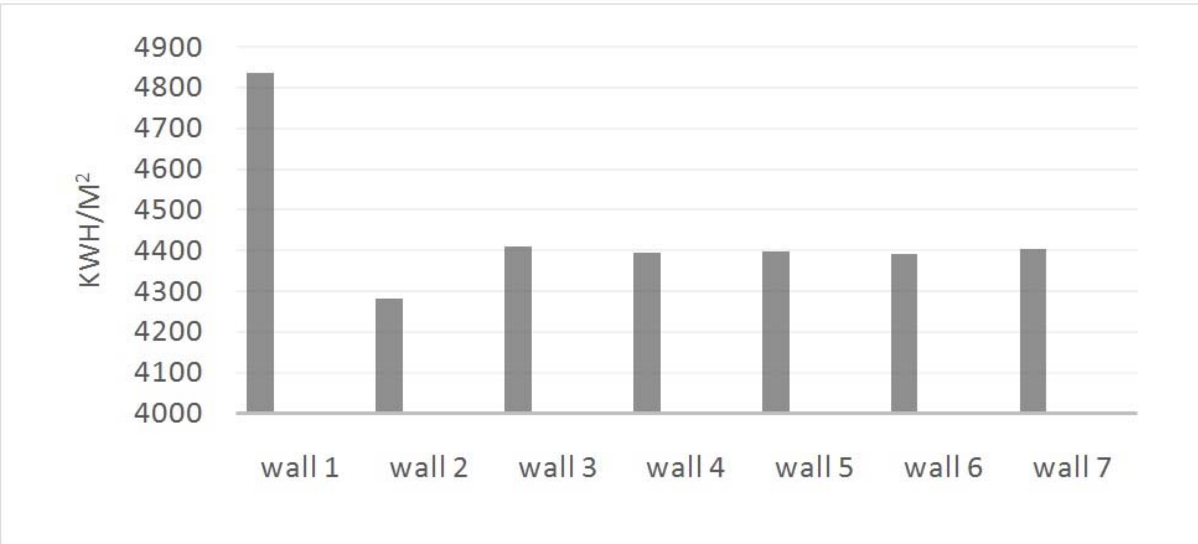

Figure 3. Annual energy consumption

Conclusion

The Number of seven wall assemblies were investigated to assess the impact of insulation location and distribution of common walling on energy consumption in Northern Cyprus buildings. A dynamic thermal simulation using EDSL Tas was employed and hourly climate references of Famagusta were applied. The result indicated significant difference on the overall energy consumption of a non-insulated assembly (wall 1) compared to the others (wall 2-7) particularly wall 2, had the best performance which was the least in this investigation. Briefly it can be consequent that if insulation layer locates in the outside of the walls the best performance will be obtained. The outcomes from this study will be applied to the resumption of the future studies discussed previously and also can be definitely applicable to the neighboring cities.

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